

What is claimed is:

- 1           1.       A reverse spreading device for reversely spreading  
2 complex base band signal, one being composed of an I (In-phase  
3 signal) component and another being composed of a Q (Quadrature  
4 phase signal) component and each being spread using spread codes  
5 of n-pieces of chips for one symbol signal comprising:  
6           a first correlator having first delay devices whose number  
7 is an integral multiple of n-1 and which sequentially shift said  
8 base band signal composed of said I component by delaying it at  
9 a predetermined time interval, having n-pieces of first multipliers  
10 each performing a multiplication between said base band signal  
11 composed of said I component shifted by said first delay devices  
12 and a spread code and having m-pieces of first adders each performing  
13 integration of an output from k-pieces of said first multipliers  
14 out of n-pieces of said first multipliers and outputting the result  
15 of said integration as an intermediate signal composed of said  
16 I component ( $m=n/k$ );  
17           a second correlator having second delay devices whose number  
18 is the same as that of chips for one symbol signal sequentially  
19 shifted by delaying said base band signal composed of said Q  
20 component at a predetermined time interval, having n-pieces of  
21 second multipliers each performing a multiplication between said  
22 base band signal composed of said I component sequentially shifted  
23 by said second delay devices and said spread code and having m-pieces  
24 of second adders each performing integration of an output from  
25 k-pieces of said first multipliers out of n-pieces of said first  
26 multipliers and outputting the result of said integration as an  
27 intermediate signal composed of said Q component;

28 m-pieces of phase rotators each performing a rotation  
29 correction by phase-rotating m-pieces of said intermediate signals  
30 each being composed of said I component produced by each of said  
31 first correlators and m-pairs of complex intermediate signals  
32 containing m-pieces of intermediate signals composed of said Q  
33 component produced by said each of said second correlators, on  
34 a complex plane at a phase rotation angle at m-stages each being  
35 slid by a reference rotation angle for every pair of said complex  
36 intermediate signals;

37           a first adder to perform calculation of a correlation value  
38   composed of said I component by doing integration of said I component  
39   of said m-pieces of said complex intermediate signals obtained  
40   after said rotation correction is made by each of said phase  
41   rotators; and

42           a second adder to perform calculation of a correlation value  
43   composed of said Q component by doing integration of said Q component  
44   of said m-pieces of said complex intermediate signals obtained  
45   after said rotation correction of each of said phase rotators is  
46   made.

1           2.       A reverse spreading device for reversely spreading  
2   complex base band signals, one being composed of an I (In-phase  
3   signal) component and another being composed of a Q (Quadrature  
4   phase signal) component and each being spread using spread codes  
5   of n-pieces of chips for one symbol signal comprising:

6           a first multiplier to sequentially perform a multiplication  
7   between base band signals composed of said I component and said  
8   spread codes of n-pieces of chips;

9        a first correlator to produce m-pieces of intermediate

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10 signals composed of said I component by sequentially integrating  
11 said multiplied value obtained by said first multiplier for every  
12 k-pieces and by using said multiplied value as said intermediate  
13 signal and to output them as  $(m=n/k)$ ;

14 a second multiplier to sequentially perform a multiplication  
15 between said base band signals composed of said Q component and  
16 said spread codes of n-pieces of chips;

17 a second correlator to produce m-pieces of intermediate  
18 signals composed of said Q component by sequentially integrating  
19 said multiplied value obtained by said first multiplier for every  
20 k-pieces multiplied values and by using said multiplied value as  
21 said intermediate signals and to output them;

22 a phase rotator to perform a rotation correction by  
23 phase-rotating m-pieces of complex intermediate signals  
24 containing said intermediate signal composed of said I component  
25 and said intermediate signal each composed of said Q component  
26 on a complex plane at a phase rotation angle at m-stages each being  
27 slid by a reference rotation angle for every pair of said complex  
28 intermediate signals;

29 a first adder to perform calculation of a correlation value  
30 composed of said I component by doing integration of said I component  
31 of said m-pieces of said complex intermediate signal obtained after  
32 said rotation correction by each of said phase rotators is made;  
33 and

34 a second adder to perform calculation of a correlation value  
35 composed of said Q component by doing integration of said Q component  
36 of said m-pieces of said complex intermediate signals obtained  
37 after said rotation correction by each of said phase rotators is  
38 made.

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1           3.     A reverse spreading device for reversely spreading  
2     complex base band signals, one being composed of an I (In-phase  
3     signal) component and another being composed of a Q (Quadrature  
4     phase signal) component and each being spread using spread codes  
5     of n-pieces of chips for one symbol signal comprising:  
6           a frequency error correcting device to count how many chips  
7     of said complex base band signals to be inputted and to perform  
8     a rotation correction in a step-by-step manner by rotating a phase  
9     of said complex band signals on a complex plane at a phase rotation  
10    angle at m-stages each being slid by a reference rotation angle  
11    being an angle obtained by dividing a rotation angle ( $2\pi$ ) of a  
12    revolution to M portions every time a count of the chips increases  
13    by K-chip;  
14           a spread code multiplier to multiply each of complex base  
15    band signals obtained after the rotation correction by said  
16    frequency error correcting device is made, by said spread codes;  
17    and  
18           two accumulative adders to produce a correlation value  
19    composed of said I component and a correlation value composed of  
20    said Q component by performing accumulative addition of multiplied  
21    value from said spread code multiplier for one symbol period for  
22    each of said I component or Q component.

1           4.     The reverse spreading device according to Claim 3,  
2     wherein said frequency error correcting device is composed of a  
3     chip number counter to sequentially count how many chips of said  
4     complex base band signal to be inputted and to provide an instruction  
5     for incrementing every time when count of chips increases by K-chips,  
6     of a step number counter to increase said step number by one if

7 the outputted step number is a number other than M-1 and to return  
8 said step number to 0 if said step number is M-1 in accordance  
9 with said instruction for incrementing fed from said chip number  
10 counter and of a phase rotator to perform a rotation correction  
11 by rotating a phase of said complex base band signals at a phase  
12 rotation angle corresponding to a step number fed from said step  
13 number counter, out of phase rotation angles at M stages slid by  
14 said reference rotation angle.

1           5.       The timing detecting device comprising said reverse  
2   spreading device claimed in Claim 1 and a peak detecting circuit  
3   to detect spreading timing based on sizes of correlation values  
4   of said I component and said Q component obtained by said reverse  
5   spreading in said reverse spreading device.

1           6.       The channel estimating device comprising said reverse  
2   spreading device claimed in Claim 1 and a rotation correcting  
3   circuit to detect a phase error contained in a complex symbol  
4   obtained by said reverse spreading device and to perform correction  
5   of said phase error.

1           7.       The timing detecting device comprising said reverse  
2   spreading device claimed in Claim 2 and a peak detecting circuit  
3   to detect spreading timing based on sizes of correlation values  
4   of said I component and said Q component obtained by said reverse  
5   spreading in said reverse spreading device.

1           8.       The channel estimating device comprising said reverse  
2   spreading device claimed in Claim 2 and a rotation correcting

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3 circuit to detect a phase error contained in a complex symbol  
4 obtained by said reverse spreading device and to perform correction  
5 of said phase error.

1 9. The timing detecting device comprising said reverse  
2 spreading device claimed in Claim 3 and a peak detecting circuit  
3 to detect spreading timing based on sizes of correlation values  
4 of said I component and said Q component obtained by said reverse  
5 spreading in said reverse spreading device.

1 10. The channel estimating device comprising said reverse  
2 spreading device claimed in Claim 3 and a rotation correcting  
3 circuit to detect a phase error contained in a complex symbol  
4 obtained by said reverse spreading device and to perform correction  
5 of said phase error.

1 11. A method for measuring a frequency error being a  
2 difference between a reference frequency of a receiver and a  
3 reference frequency of a sender comprising steps of:

4 shifting sequentially a base band signal composed of an I  
5 (In-phase signal) component and a base band signal composed of  
6 a Q (Quadrature phase signal) component and performing a  
7 multiplication between said shifted said base band signals each  
8 being composed of said I component or said Q component;

9 performing integration of k-pieces of multiplied values out  
10 of n-pieces of multiplied values obtained and producing m-pieces  
11 of intermediate signals composed of an I component ( $m=n/k$ );

12 performing a rotation correction by rotating phases of  
13 m-pairs of complex intermediate signals including m-pieces of

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14 intermediate signals composed of said I component and m-pieces  
15 of intermediate signals composed of said Q component at a phase  
16 rotation angle at m-stages each being slid by a reference rotation  
17 angle for every one pair of complex intermediate signals;

18 calculating a correlation value of said I component and a  
19 correlation value of said Q component by integrating said I  
20 component and said Q component of said m-pieces of said complex  
21 intermediate signals obtained after said rotation correction is  
22 made; and

23 calculating a power value of a complex symbol based on said  
24 correlation values of said I component and said Q component and  
25 selecting said reference rotation angle so that said power value  
26 becomes maximum and then detecting said frequency error based on  
27 said reference rotation angle selected.

1 12. A method for measuring a frequency error being a  
2 difference between a reference frequency of a receiver and a  
3 reference frequency of a sender comprising steps of:

4 performing a multiplication between base band signals, one  
5 being composed of an I component of n-pieces of chips and another  
6 being composed of a Q component of n-pieces of chips and spread  
7 code of n-pieces of chips and producing m-pieces of intermediate  
8 signals, one being composed of said I component and said Q component  
9 by integrating a multiplied value for every k-pieces of said  
10 multiplied value and to use an integrated value as an intermediate  
11 signal ( $m=n/k$ );

12 performing a rotation correction by rotating phases of  
13 m-pairs of complex intermediate signals including m-pieces of  
14 intermediate signals composed of said I component and m-pieces

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15 of intermediate signals composed of said Q component at a phase  
16 rotation angle at m-stages each being slid by a reference rotation  
17 angle for every one pair of complex intermediate signals;

18           calculating a correlation value of said I component and a  
19 correlation value of said Q component by integrating said I  
20 component and said Q component of said m-pieces of said complex  
21 intermediate signals obtained after said rotation correction is  
22 made; and

23           calculating a power value of a complex symbol based on said  
24   correlation values of said I component and said Q component and  
25   selecting said reference rotation angle so that said power value  
26   becomes maximum and then detecting said frequency error based on  
27   said reference rotation angle selected.

1           13.     A method for measuring a frequency error being a  
2     difference between a reference frequency of a receiver and a  
3     reference frequency of a sender comprising steps of:

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4      counting how many chips of complex base band signals are
5  to be inputted;
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6 performing a rotation correction in a step-by-step manner  
7 by rotating a phase of said complex band signal on a complex plane  
8 at a phase rotation angle at m-stages each being slid by a reference  
9 rotation angle being an angle obtained by dividing a rotation angle  
10 ( $2\pi$ ) of a revolution to M portions every time said counted number  
11 of the chips increases by K- chip

12 multiplying complex base band signals by spread signals  
13 obtained after the rotation correction is made by said frequency  
14 error correcting device;

15           producing a correlation value of the I component and a

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16 correlation value of the Q component by adding the multiplied value  
17 fed from said spread code multiplier in an accumulative manner  
18 for every I component and every Q component during one symbol period;  
19 calculating a power value of the complex symbol based on  
20 the correlation values of said I component and said Q component  
21 and selecting said reference rotation angle so that the power value  
22 becomes maximum and then detecting said frequency error based on  
23 said reference rotation angle selected.

1 14. An AFC (Automatic Frequency Control) method to control  
2 a frequency of a reference frequency signal of a mobile station  
3 so that a frequency error measured by said frequency error measuring  
4 method claimed in claim 11.

1 15. An AFC (Automatic Frequency Control) method to control  
2 a frequency of a reference frequency signal of a mobile station  
3 so that a frequency error measured by said frequency error measuring  
4 method claimed in claim 12.

1 16. An AFC (Automatic Frequency Control) method to control  
2 a frequency of a reference frequency signal of a mobile station  
3 so that a frequency error measured by said frequency error measuring  
4 method claimed in claim 13.

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